M.Sc. 4th Semester Examination, 2025
PHYSICS

PAPER — PHY-403.1 & 403.2

Full Marks : 50

Time : 2 hours

Answer **all** questions

The figures in the right hand margin indicate marks

Candidates are required to give their answers in their own words as far as practicable

PHS — 403.1

(*Transport Properties and Semiconductor Devices*)

GROUP — A

1. Answer any *two* questions :　　　　　2 × 2

    (*a*) Describe with a neat diagram the band structure of the material which leads to Gunn Effect Oscillations.

(b) What is the principle of photodetection using a photodiode ?

(c) Find the dependence of mobility on temperature for a nondegenerate semi-conductor.

(d) Find the surface potential ϕ_F correspon-ding to inversion in a capacitor on p-type Si with $N_a = 10^{15} cm^{-3}$ at room temperature and $n_i = 1.5 \times 10^{10} cm^{-3}$

GROUP – B

2. Answer any *two* questions :   4 × 2

(a) Explain how drift mobality of minority carriers can be experimentally determined by Haynes Schockley Experiment.

(b) Explain quantum Hall effect and hence find an expression of Hall voltage.

(*Continued*)

(c) Derive the relation between electron temperature and lattice temperature assuming Gunn effect oscillation.

(d) Prove that for lasing action to occur in a semiconductor laser diode the n & p region must be heavily doped.

GROUP – C

3. Answer any *one* question : 8 × 1

(a) (i) Describe with neat band diagram the operation of tunnel diode under forward bias condition.

(ii) Clearly explaining the bipolar transitor (pnp) action (for common base configuration) with band diagram, find an expression of emitter current due to hole. 4 + 4

(b) (i) Describe the p-n-p-n diode operation and hence find an expression of current i through the device using two transistor analogy.

(ii) How the interfacial layer is created in a MOSFET when the gate bias is sufficiently increased ?

PHS — 403.2

(*Applied Optics*)

GROUP — A

1. Answer any *two* of the following questions :

$$2 \times 2$$

(a) What are the advantages of optical fiber communication over electronic communication ?

(b) The mean optical power launched into 8 Km length of fibre is 120 μW. The mean optical power at the fibre output is 3 μW. Find the signal attenuation per Km.

(c) Provide two examples of nonlinear optical materials.

(d) Construct tri-state NOT gate.

GROUP – B

2. Answer any *two* of the following questions :

4×2

(a) An optical fiber has a core refractive index of $n_1 = 1.47$ and a core radius of $a = 5$ μm. Calculate the effective refractive index n_{eff} for the following wavelengths 1.31 μm and 1.55 μm. Comment on how the effective refractive index changes with wavelength.

(b) A Gaussian laser beam with an input beam radius of 0.5 mm and peak electric field $E_0 = 2.0 \times 10^7$ V/m enters a nonlinear optical medium with linear refractive index $n_0 = 1.5$ and nonlinear index $n_2 = 1.2 \times 10^{-19}$ m²/W. Calculate the self-focusing length 1.

(c) How is the wavefront reconstructed in a hologram ? Explain the process with the help of a labeled diagram.

(d) Explain the working principle of Photo-multiplier Tubes with a diagram and mention their applications.

GROUP — C

3. Answer any *one* of the following questions :

8×1

(a) An optical fibre has core diameter of 6 μm and core refractive index is 1.45. The critical angle is 87°. Calculate the refrective index of the cladding, acceptance angle, normalized frequency, and number of guided modes in through fibre when wavelength is 1 μm. $2 + 2 + 2 + 2$

(b) (i) What happens when two light waves with frequencies v_1 and v_2, propaga-

ting in the z-direction with velocities v_1 and v_2, and describe by

$$E_1 = E_{01} \cos\left[2\pi\upsilon_1\left(t - z/V_1\right)\right] \text{ and}$$

$$E_2 = E_{02} \cos\left[2\pi\upsilon_2\left(t - z/V_2\right)\right],$$

are incident on a nonlinear optical material ?   4

(ii) What are the advantages of parallel processing ? How can parallel processing be implemented in optics ?   2 + 2

[Internal Assessment — 10 Marks]